

**Validation Of Top-Of-Atmosphere Longwave Radiative Flux**

**Estimates From CERES/TRMM SSF Edition-2**

**Angular Distribution Models**

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*CERES STM, January 2002, Brussels, Belgium*

## EMPIRICAL APPROACH (SSF Edition-2 ADMs)

Longwave Flux:  $F = \int L(\theta) \cos\theta d\Omega = 2\pi \int_0^{\pi/2} L(\theta) \cos\theta \sin\theta d\theta$

Anisotropic Emission Factor:  $R(\theta) = \frac{\pi L(\theta)}{F}$

$R(\theta)$  empirically defined as function of

- Surface Type
- Cloud Fraction
- Cloud Emissivity
- Precipitable Water
- Vertical Temperature Change

## MODEL PARAMETERIZATION

C.J. Stubenrauch *et al*, Journal of Applied Meteorology, 848 (1993).

Atmospheric Pseudoabsorption:

$$A = 1 - \frac{L(\theta)}{\int_{5\mu m}^{100\mu m} B(T_B, \lambda) d\lambda} = 1 - \frac{L(\theta)}{(\sigma/\pi) T_B^4(\theta)}$$

$T_B(\theta)$  - brightness temperature (using 10.8  $\mu m$  VIRS channel)

Anisotropic Emission Factor:

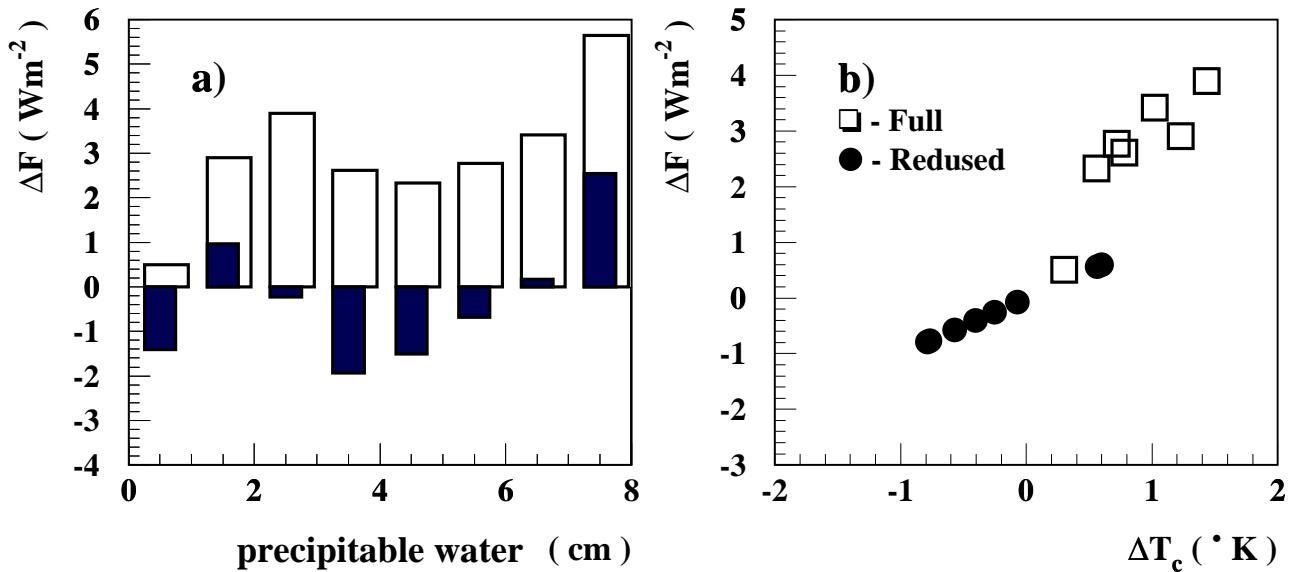
$$R = 1 + [0.55 - \exp(-\cos\theta)] A$$

## REDUCED RESOLUTION CERES FOV

### SSF Edition-2, Overcast Clouds

$$\Delta F = F(\theta < 30^\circ) - F(\theta > 40^\circ)$$

$$\Delta T_c = T_c(\theta < 30^\circ) - T_c(\theta > 40^\circ)$$



### Weighted Mean Values

Full Resolution FOV (transparent) 2.96  $\text{W m}^{-2}$

Reduced Resolution FOV (black) - 0.46  $\text{W m}^{-2}$

## DATA SAMPLE

### ● All-sky scenes

**SSF Edition-2** CERES 8-months RAPS, 1998, daytime  
VIRS coverage > 70%  
Full resolution CERES FOV

**ERBE-like** CERES 8-months RAPS, 1998, daytime  
NO unknown scene ID  
Full resolution CERES FOV

### ● Clear-sky, Broken and Overcast Cloud Scenes

**SSF Edition-2 & ERBE-like**

CERES 8-months RAPS, 1998, daytime  
VIRS coverage > 70%  
Reduced resolution CERES FOV, 60 km

**Clear-sky:** CLF > 0.1%

**Broken Clouds:** 0.1% < CLF < 99%

**Overcast Clouds:** CLF > 99%

### ● Comparison with the model

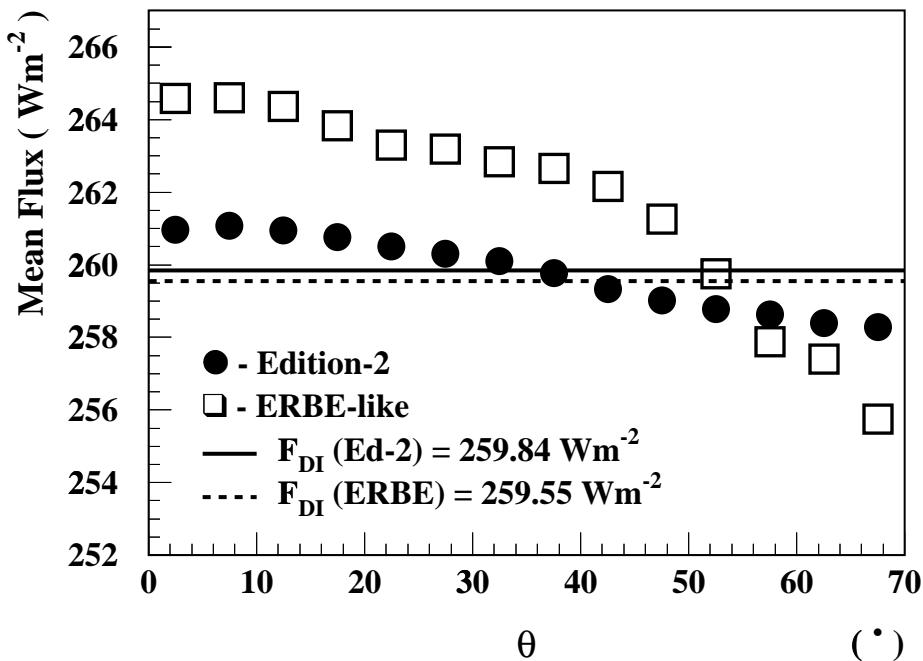
**SSF Edition-2** CERES 8-months cross-track, 1998, daytime  
VIRS coverage > 70%  
Reduced resolution CERES FOV, 60 km

**Scene ID:** Clear-sky  
Overcast clouds with  $\epsilon > 0.9$

### ● Instantaneous Flux Errors

**SSF Edition-2** CERES 9-days along-track, 1998, daytime  
VIRS coverage > 70%  
Full resolution CERES FOV  
Matching distance < 5 km

**ALL-SKY**  
**Full Resolution CERES FOV**

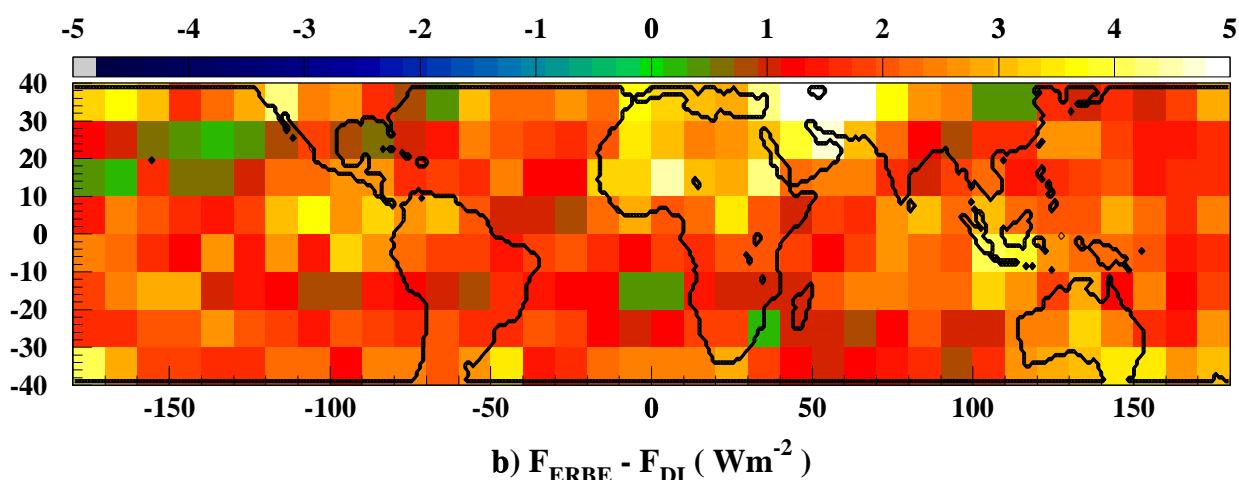
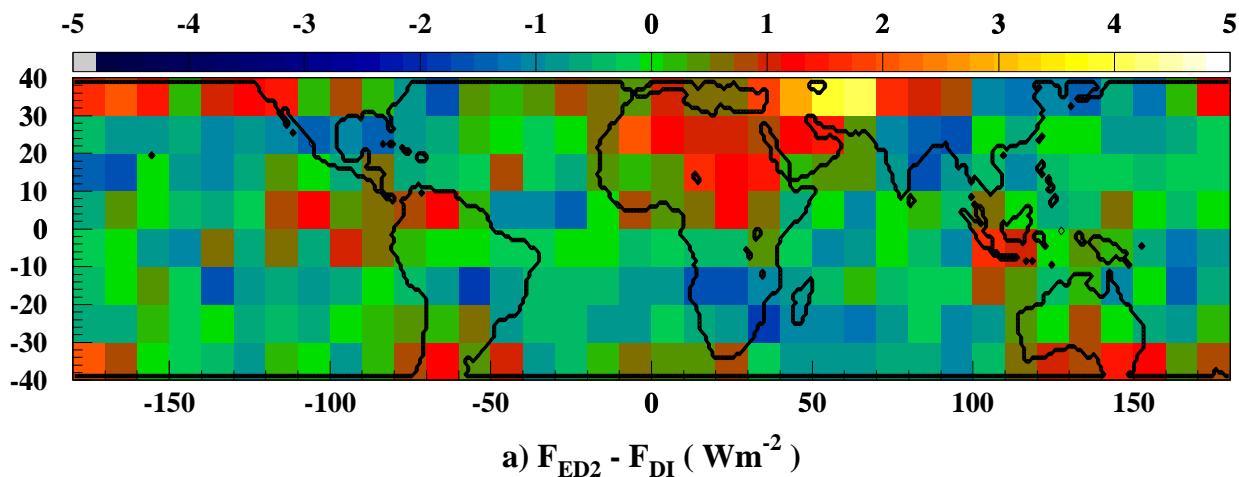


Overall Mean Flux

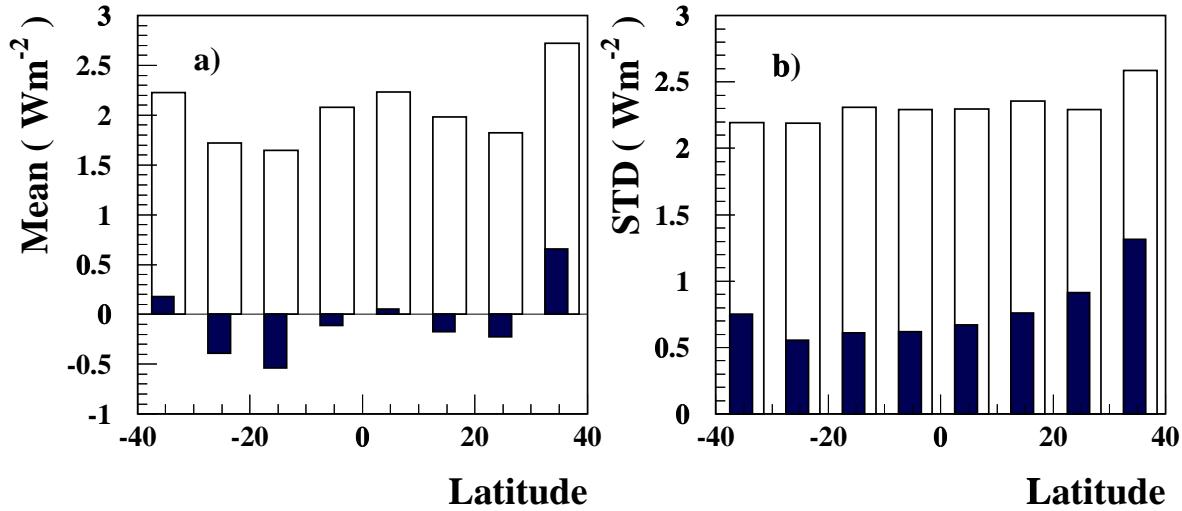
$$F_{ED-2} = 259.78 \text{ Wm}^{-2}$$

$$F_{ERBE} = 261.68 \text{ Wm}^{-2}$$

ALL-SKY REGIONAL DIFFERENCE  
 $F - F_{DI}$



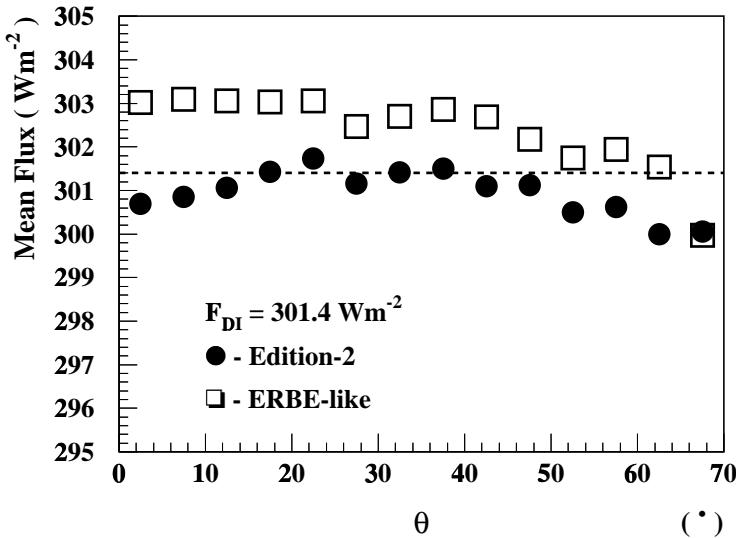
**LONGITUDINAL MEAN AND STD  
OF THE DIFFERENCE**  
 **$F - F_{DI}$**



Overall Mean ( $F_{ED-2} - F_{DI}$ ) =  $-0.069 \text{ Wm}^{-2}$

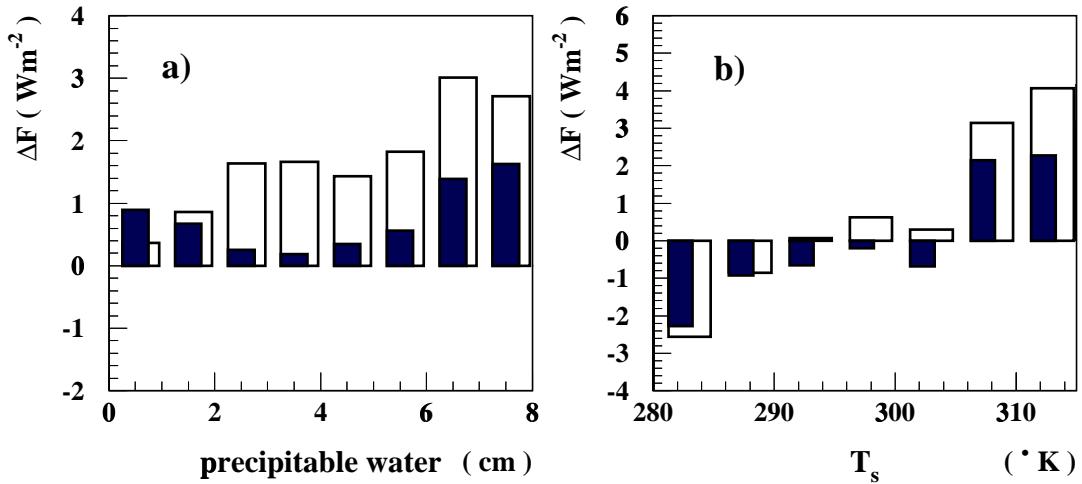
Overall Mean ( $F_{ERBE} - F_{DI}$ ) =  $2.054 \text{ Wm}^{-2}$

**CLEAR-SKY SCENES**  
**Reduced Resolution CERES FOV**



Overall Mean Flux

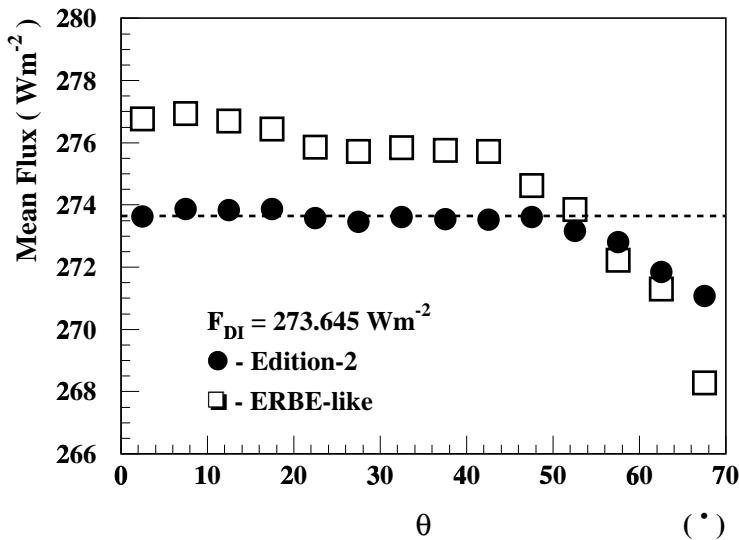
$$F_{ED-2} = 300.95 \text{ Wm}^{-2} \quad F_{ERBE} = 302.38 \text{ Wm}^{-2}$$



Weighted Mean Values

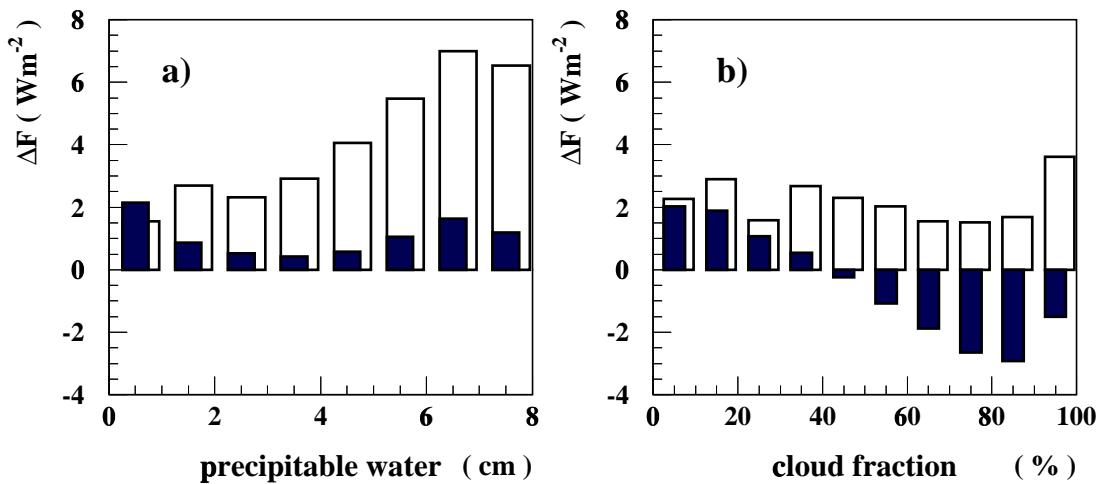
	PW	$T_s$
SSF Edition-2 (black)	$0.52 \text{ Wm}^{-2}$	$-0.13 \text{ Wm}^{-2}$
ERBE-like (transparent)	$1.16 \text{ Wm}^{-2}$	$0.62 \text{ Wm}^{-2}$

**BROKEN CLOUD FIELDS**  
**Reduced Resolution CERES FOV**



Overall Mean Flux

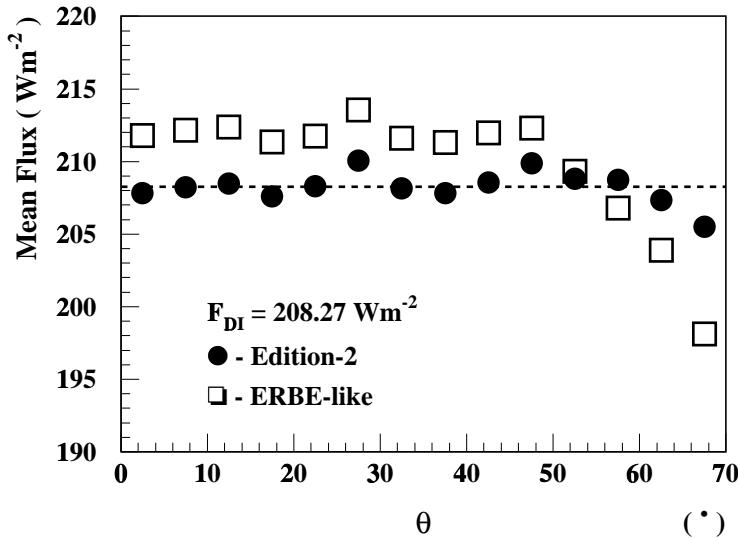
$$F_{\text{ED-2}} = 273.25 \text{ Wm}^{-2} \quad F_{\text{ERBE}} = 274.72 \text{ Wm}^{-2}$$



Weighted Mean Values	PW	CLF
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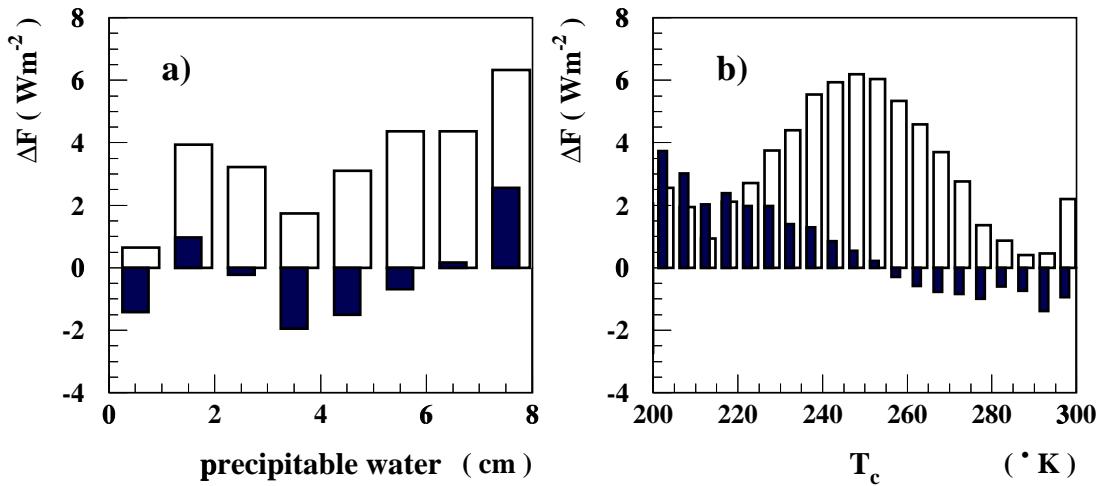
SSF Edition-2 (black)	$0.78 \text{ Wm}^{-2}$	$-0.26 \text{ Wm}^{-2}$
ERBE-like (transparent)	$3.74 \text{ Wm}^{-2}$	$2.33 \text{ Wm}^{-2}$

**OVERCAST CLOUD LAYERS**  
**Reduced Resolution CERES FOV**



Overall Mean Flux

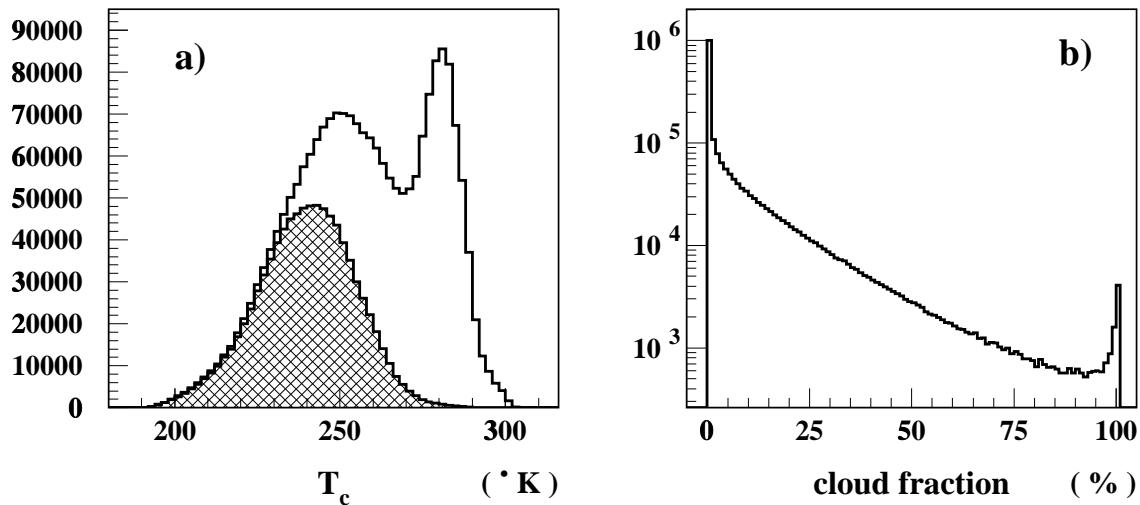
$$F_{ED-2} = 208.24 \text{ Wm}^{-2} \quad F_{ERBE} = 209.88 \text{ Wm}^{-2}$$



Weighted Mean Values

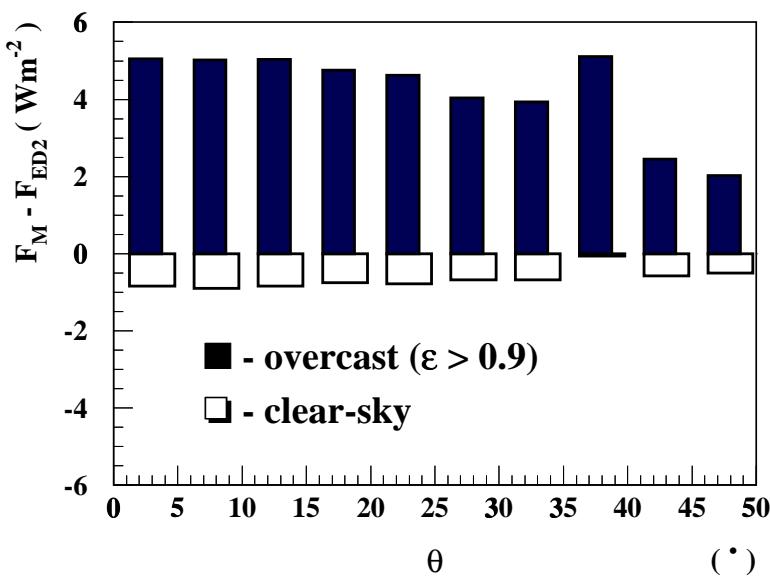
	PW	$T_C$
SSF Edition-2 (black)	$-0.46 \text{ Wm}^{-2}$	$0.14 \text{ Wm}^{-2}$
ERBE-like (transparent)	$3.39 \text{ Wm}^{-2}$	$3.69 \text{ Wm}^{-2}$

**ERBE SCENE ID**  
**Reduced Resolution CERES FOV**



- a. Cloud-top temperature of overscast clouds for SSF Edition-2 (transparent) and ERBE (hatched) scene ID.
- b. Cloud fraction of clear-sky scenes according ERBE scene ID.

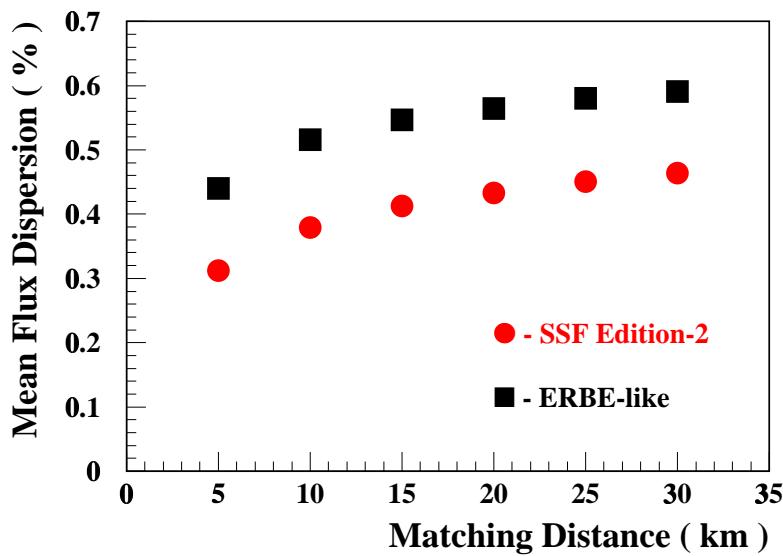
**COMPARISON WITH THE MODEL**  
**Reduced Resolution CERES FOV, Cross-Track**



**INSTANTANEOUS FLUX ERRORS**  
**Full Resolution CERES FOVs, Along Track**

- CUTS •  $\theta$  dispersion in collocation  $> 25\%$   
 • Cloud layer height within collocation  $\pm 0.1$  km

**Clear-sky Ocean Scene Collocation**

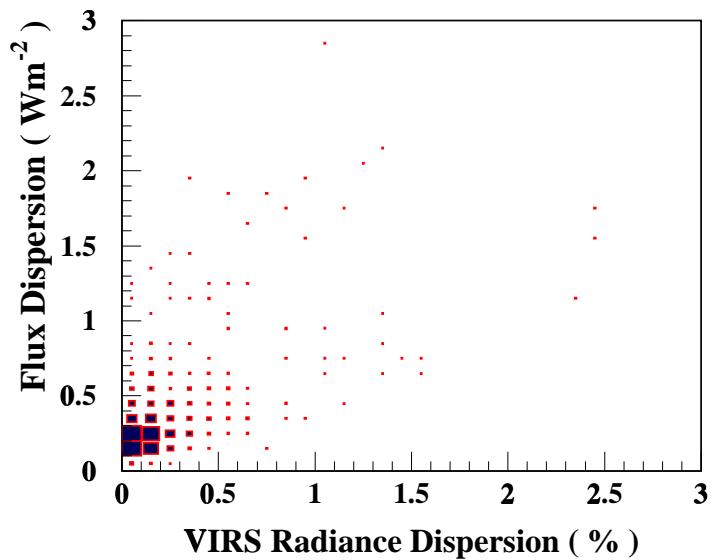


**Mean Flux Dispersion with Matching Distance  $< 5$  km**

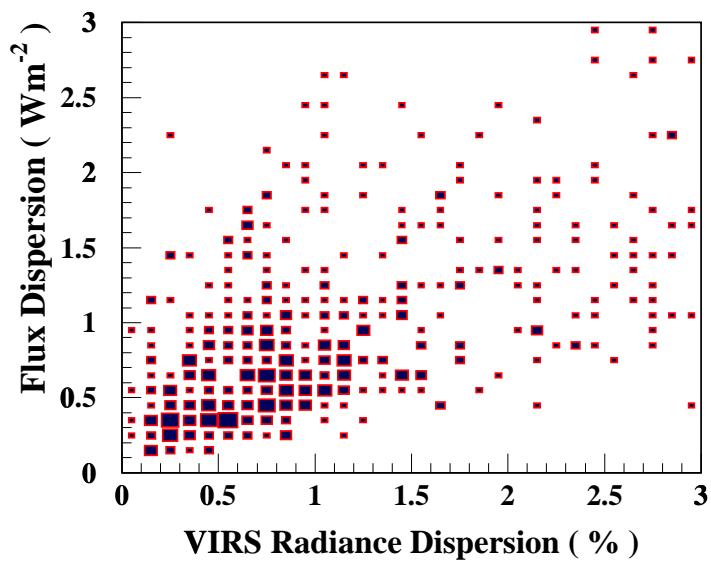
Scene type	Surface	$F_{ED2}$ (Wm $^{-2}$ )	$\sigma_{ED2}$ (%)	$F_{ERBE}$ (Wm $^{-2}$ )	$\sigma_{ERBE}$ (%)	$\sigma_{IM}$ (%)
Clear-sky	ocean	289.3	0.312	290.4	0.437	0.177
	land	298.9	0.434	300.2	0.462	0.464
	desert	312.6	0.498	315.3	0.570	0.504
Overcast Clouds	ocean	220.1	1.773	224.3	1.802	1.922
	land	197.6	1.987	200.6	1.993	2.491

## SPATIAL INHOMOGENEITY IN COLLOCATED SAMPLES

Clear-Sky Ocean



Overcast Clouds over Ocean



## SUMMARY

- Further differentiation in scene definition of Edition-2 ADMs allows to reduce significantly the longwave flux errors. All-sky average regional flux difference with directly integrated flux for Edition-2 ADMs is below  $0.1 \text{ Wm}^{-2}$  in comparison with  $2 \text{ Wm}^{-2}$  for ERBE ADMs.
- Application of the reduced resolution CERES FOV technique improves uniformity in selected data sample for all scene types.
- The SSF Edition-2 longwave fluxes have smaller remaining dependence on CERES viewing zenith angle than ERBE-like fluxes for all scene types. The remaining anisotropy of SSF Edition-2 fluxes, stratified in precipitable water, surface temperature, cloud-top temperature and cloud fraction is greatly reduced in comparison with that of ERBE-like fluxes.
- Longwave fluxes are well reproduced by the parameterization model for clear-sky scenes (within  $1 \text{ Wm}^{-2}$ ). However, the model overestimates fluxes for overcast scenes with large emissivity for about  $3 \text{ Wm}^{-2}$ , mostly due to inhomogeneity in clouds cover not accounted for in the plane-parallel atmosphere approach.
- Total instantaneous uncertainty of SSF Edition-2 fluxes are within 0.5% for clear-sky scenes. For overcast cloud scenes the instantaneous uncertainty is dominated by spatial inhomogeneity in data sample.